

## Who is interacting with researchers on Twitter? A survey in the field of Information Science

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### ABSTRACT

The social web appears a promising environment to study the societal impact of research, and, although platforms such as Twitter appear to be popular to share scientific content, little is known about the outreach of scientific communication on social media. By surveying a sample of Twitter users who are also followers of communication and Library and Information Science (LIS) researchers, this article aims to understand who is interacting with researchers on Twitter and if the activity of following allows to get closer to science and research. A survey was sent to all followers of 9 active researchers, and 53 responses were collected and analyzed. According to the results, followers are mostly professionals (49%) although the higher education sector (36%) accounts for an important part of the audience. Twitter allows respondents to keep updated, feel as a part of the scientific community and gain more visibility, whereas interactions appear as an important though secondary facet of these users' activity on Twitter. Finally, participants consider that they do not have influence on the scientific process, maybe because the flow of information on Twitter occurs mostly as retweeting in an unidirectional fashion. More research is needed in order to understand better interactions and engagement on social media before they can be quantified and measured as indicators of societal impact of research.

### ACKNOWLEDGEMENTS

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### KEYWORDS

Altmetrics; Societal Impact of Research; Communication; Library and Information Science; Twitter; Social Media Interactions.

### CITATION

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## 1. Introduction

Altmetrics or social media metrics measure the impact of research when scientific communication takes place on the social web. Moving from the closed scientific system to the web, altmetrics present several advantages over traditional citation metrics (Priem, Taraborelli, Groth *et al.* 2010). They can be harvested sooner than citation-based indicators and they can capture the impact of research outside the academic community, allowing in this way to measure impact of research products different from the research article. Since 2010, much research has been carried out. Many studies, if not most of them, have relied on correlation analysis in order to find meaningful relationships between mentions of scientific articles on social media and their respective citations in citation indexes. According to Bornmann (2014), however, the results obtained by correlation studies are “hardly meaningful and can be interpreted fairly loosely” (p. 901). When positive correlations are found, meaning that altmetrics have something to do with scholarly activity, it is argued that social web metrics should not be considered alternative metrics because they align with traditional metrics. On the other hand, when correlations between social web mentions and citations are weak, and consequently their ties to scientific communication appear to be looser, it is argued that altmetrics measure a *different dimension* of impact, specifically the societal impact of research (Bornmann 2015). Unfortunately, the concept itself of societal impact of research is still vague and difficult to measure (Bornmann 2013), whilst metrics from social media appear to be more reliable when they originate in relatively closed environments such as Mendeley. Indeed, the most robust source of social metrics seems to be Mendeley (Thelwall and Kousha 2015), a social reference manager, whose users are mostly young academics, i.e. PhD students, postgraduates and postdocs across different disciplines (Mohammadi, Thelwall, Haustein *et al.* 2015). Correlations between readers on Mendeley and citations seem to have even improved over time, probably as a consequence of the growing readership of this platform (Mohammadi, Thelwall, Haustein *et al.* 2015). Being strongly related to citations, readership counts on Mendeley allow to obtain similar impact data to citations, though ahead of time. The basically academic nature of Mendeley and similar reference managers such as Figshare limits its application to measure impact on a broader non-academic audience. Bornman (2015a) found that metrics coming from Facebook and Twitter were significantly higher than metrics obtained from Mendeley and Figshare for articles published in the Public Library of Science and tagged as “good for teaching” – and thus more likely to appeal to a broader audience.

In addition to the limitations discussed above, correlation studies alone cannot prove that there exists a connection between altmetrics and research impact (Sud and Thelwall 2014), and that makes it difficult to build meaningful theories. The lack of theoretical foundations for altmetrics by itself is a frequent claim (Priem 2014; Holmberg 2015, 9.2). Haustein (2016) mentions the lack of a conceptual framework to understand the actions behind the metrics, among the other challenges of altmetrics research, whilst Haustein, Bowman and Costas (2015) try to make sense of different actions occurring on the social web, specifically access, appraise, and apply, but on the basis of pre-existing adapted theories. Different methodological approaches are needed in order to build significant theories and understand altmetrics.

### 1.1 Alternative metrics and societal impact of research

A related question which is still to be answered concerns what dimension of societal impact scientific communication on the web should reflect. Bornmann (2012; 2013) reviews different approaches to measure societal impact of research, concluding that, at the moment and considering the extreme complexity of the issue, qualitative case studies assessment seems to be the best practical approach. Greenhalgh, Raftery, Hanney, *et al.* (2016), after reviewing several approaches to assess impact within the health sciences, conclude that research impact per se can have many definitions and different approaches might be necessary depending on the purpose. On the other hand, alternative metrics can play a role in measuring societal impact of research because they make it possible to measure, to a certain extent, public engagement with research (Bornmann 2014). According to Ozanne, Davis, Murray *et al.* (2017), altmetrics allow to introduce measurement in what is still difficult to express in numbers, i.e. the engagement of the research community with society. The social web is an informal context in which engagement and interactions are made possible (Holmberg, Bowman, Haustein, *et al.* 2014). The advantages of altmetrics for measuring societal impact include the coverage of different audiences from academia, the diversity of measurable research products, the speed with which they are generated, and their openness (Bornmann 2014). On the other hand, limitations span from the dependence on commercial platforms to several issues regarding the quality of data, such as little knowledge of audiences and users, multiple versions of papers, or lack of normalization (Bornmann 2014).

Addressing the problem of the societal impact of research, some suggest we should look at the *processes* by which research contributes to social change more than at results. Spaapen and van Drooge (2011) consider that *productive interactions*, as a type of engagement, between scientists and different stakeholders may foster knowledge transfer and application. What the authors call “[...] exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant” (p. 212) allow to move the focus of evaluation from actual results, which may take time to produce and might be difficult to attribute, to the process leading to impact. Looking at the process does justice to basic research, that rarely produces visible and tangible results in applied projects (de Jong, Barker, Cox *et al.* 2013). Dilling and Lemos (2011) speak also of *iterativity*, as “the purposeful and strategic interaction between climate knowledge producers and users so as to increase knowledge usability” (p. 681). In their opinion, the demand of usable scientific knowledge to address environmental problems can only be met through iterative interactions between scientists and users of knowledge. Pedrini, Langella, Battaglia *et al.* (2018), from the health sciences, suggest implementing a multi-stakeholder perspective in health research processes in order to maximize its societal implications. In the same line of thought, Ozanne *et al.* (2017) retake the concept of productive interactions defining the “relational engagement approach” to assessing societal impact of research. This perspective emphasizes engagement with researchers of other disciplines and social stakeholders beyond actual results and products as a measure of impact on society, which points to an important limitation of altmetric research so far. Most studies carried out on altmetrics have been looking for mentions of research articles on the social web, paying attention to the most traditional research output. Conversely, the process itself of engaging or interacting on the social web has received little attention. It is unlikely that the layperson can understand the scientific literature as it is produced for other researchers and the context itself in which it has been produced

(Zuccala 2009). In the area of environmental research, Archie, Dilling, Milford *et al.* (2014), after conducting a survey about the role of information for public lands managers and municipal officials, concluded that peer-reviewed information was considered the best available knowledge, though it was used regularly by less than half of the population studied. In many cases, there might not exist relevant scientific literature for particular problems, or it might be too difficult to access and understand. The limitations of traditional scientific literature to address the needs of a no specialized audience put into question the fact that mentions of research articles on the social web should be measured as an indicator of societal impact of research. Additionally, it remains to be determined how often authors mention their own articles online as a means to gain visibility and boost impact. A recent study of an Information Science community on Twitter found that almost half of the times articles were tweeted by the authors themselves or by closed colleagues (Álvarez-Bornstein and Montesi 2016). It takes very little effort to tweet an article, whilst it requires commitment and time to really engage and interact with no academic audiences.

## 1.2 Engagement on social media

If repeated productive interactions with different stakeholders might be a way to promote societal impact of research, then it is important to understand such interactions within specific contexts. In the case of Mendeley, engagement with the community and participation in groups have been found to be less frequent activities than research-related activities (Jeng, He, and Jiang 2015). In the case of Twitter, several studies try to characterize it as for its interactive affordances. Boyd, Golder and Lotan (2010) study retweets as a way of interaction. Quan-Haase, Martin and McCay-Peet (2015), after interviewing 25 Digital Humanities scholars, conclude that being on Twitter per se is a conversation, that “takes place through a single tweet or a series of interactive tweets, and in relation to other discourses online and offline, both inside and outside their disciplines” (p. 9). On the other hand, Holmberg, Bowman, Haustein, *et al.* (2014) look at mentions, as a way of describing interactions, of Twitter users in the tweets published by a sample of 37 astrophysicists. They found that the astrophysicists studied interacted with a variety of user types including other colleagues, science communicators, such as scientific journalists, other researchers and educators.

In order to understand interactions on social media around scientific contents, it is important to know who takes part. We know little about users of Twitter for scientific and research purposes, though the academic community has been surveyed in a few studies in order to know their attitude towards social media or their presence on social platforms. Haustein, Peters, Bar-Ilan *et al.* (2014) surveyed all attendants at the 2012 STI conference of Montréal, finding that the most popular platform for these scientists was LinkedIn, whilst half of respondents reported having a Twitter account and only 1/3 had a ResearchGate or and Academia.edu account. Mas-Bleda, Thelwall, Kousha *et al.* (2014) measured the uptake of the social web as a communication tool among highly cited researchers of European institutions, finding that only 28% had an account on any of the social sites analyzed: Google Scholar, Mendeley, Academia, LinkedIn, and SlideShare. Mohammadi, Thelwall and Kousha (2016) surveyed Mendeley users in order to know if they read or intended to read the articles stored as references. It was found that 55% of Mendeley users actually had read or wanted to read at least half of the articles saved, which would mean that altmetrics extracted from Mendeley can be counted as reads. Many studies of users interacting on social media have dealt with Twitter. However, according to Budge,

Lemon, and McPherson (2016), who describe their personal experience on Twitter as academics and artists, there is a paucity of research on Twitter use by academics. Veletsianos (2012) characterizes seven main activities of scholars using Twitter on the basis of a sample of tweets from 45 scholars in several disciplines. Among these activities, he mentions sharing information both for their professional practice and classroom, requesting and offering suggestions, engaging in social commentary, or shaping their digital identity. Haustein and Costas (2015) define automatically the profiles of approximately 80000 Twitter accounts tweeting academic articles. They find that users tweeting academic articles describe themselves as organizations or interest groups, professionally, personally or both. Na (2015) describes users' motivations when they tweet research articles in psychology, relying on content analysis of the short messages exchanged on this microblogging platform. Studying a group of 37 astrophysicists on Twitter, Haustein, Bowman, Holmberg *et al.* (2014) found moderately negative correlations between tweets per day and the number of publications in a five year timespan (2008-12), meaning that those who tweet more intensely tend to publish less scientific literature.

Despite all this literature on Twitter users, little do we know about followers of researchers on Twitter. With no doubt it is a difficult topic to explore, because, due to the asymmetric nature of Twitter in which anyone can follow anyone, many users do not know all their followers (Gruzd, Wellman and Takhteyev 2011), and it is difficult to reach to them. This knowledge gap about users of media platforms makes it difficult to estimate how biased they are as sources of altmetrics data (Bornmann 2014). The purpose of this article is to survey a sample of Twitter users who are also followers of Library and Information Science (LIS) researchers, in order to know if the fact of following researchers get them closer to science and research. Twitter appears to be the most popular space in which to share scientific content (Holmberg *et al.* 2014). Pooling results of research into altmetrics in a meta-analysis, Bornmann (2015, 27) concluded that: "Twitter and blog citations seem to measure something different from traditional citations, because the pooled coefficients are very low." Haustein, Costas and Larivière, (2015) look for traces on the social web of 1.3 millions documents extracted from Web of Science, finding that the most popular platform they were mentioned on was Twitter (22% of documents had at least a tweet). Both blogs and Twitter are spaces in which interactions between the academia and different social actors are possible.

## 2. Method

Researchers studying altmetrics often claim that more qualitative research designs, such as interviews and surveys, are needed to understand scientific communication on the web (Holmberg 2015, 14.3). In this research article, we present results of a web survey with Twitter users, though we understand that surveys are *quantitative* research methods that allow to describe a population based on a representative sample (Pickard 2013, 111). A conceptual difference that this type of contribution can make from previous altmetrics research is that we switch from objects or events (such as mentions, tweets, citations, articles...) to persons, in this specific case, Twitter users. Focusing on research articles in order to study societal impact of research might lead to dead ends provided they seem to be shared among small communities that are little connected with the general public (Alperin, Gomez and Haustein 2018). In information behavior research, a similar transition from systems to persons occurred in the seventies when research started to deal with needs and uses instead of artifacts and



venues of information seeking (Case 2016, 7–10). In this sense, we interpret the qualitative approach that many altmetrics researchers are asking for as a claim to look at behaviors instead of objects, or at processes instead of results, as commented previously in the introduction. This is something that implicitly appears also in (Haustein, Bowman and Costas 2015) when they try to explain altmetrics through pre-existing theories by focusing on *acts* leading to online events.

## 2.1 The sample

A short survey was designed to collect information about users' identities and professions, reasons and expectations for following a particular group of twenty active researchers in Library and Information Science on Twitter. This specific group was obtained from two previous studies, (i.e. Torres-Salinas and Milanés-Guisado 2014 and Álvarez-Bornstein and Montesi 2016). Torres-Salinas and Milanés-Guisado (2014) studied the presence on social media of very active researchers who published at least 3 articles in the scientific journal *El Profesional de la Información* between 2009 and 2013. *El Profesional de la Información* is a scientific journal which is highly regarded in Spain within the Communication and LIS community. On the other hand, Álvarez-Bornstein and Montesi (2016) selected from this sample only those who had a Twitter profile in order to analyze their communication activities (26, though 6 were not active on Twitter). Thus, the sample studied here includes all followers of the 20 active researchers with a profile on Twitter that the previous literature just commented on has studied.

The 20 researchers were contacted via email, on July 5<sup>th</sup>, 2016, and, after the purpose of the research was explained, they were asked to publish a link to our survey on Twitter. Only nine of them tweeted the link. When the survey was sent, the 9 researchers who tweeted the link gathered, together, a population of 24,239 followers. It was not determined how many of these followers followed more than one of the 9 researchers who tweeted the link to the survey. Though following more than one of the 9 researchers is a very likely scenario.

Finally, 53 Twitter followers responded to the survey.

## 2.2 The survey

The survey consisted of 15 questions organized in two parts. In the first part, a set of open-ended and close-ended questions examined the use of Twitter and the reasons for following researchers. Additionally, participants were questioned about the advantages of following this group of researchers and about the way in which this activity of following contributed to their career. The second part included questions about respondents' personal and professional profile, such as sex, age, main occupation and area of specialization. These demographic data were collected in order to answer the question of *who is following researchers* on Twitter. We understood that it is important to know if they are professionals or if they work in the academia, and if they belong to LIS or other disciplines.

## 2.3 Limitations and difficulties of conducting a survey with followers on Twitter

The non-random convenience sample of 53 respondents is clearly too small to be representative of the entire population. On the other hand, it is probably impossible to obtain a representative sample of Twitter users who follow a specific group of people due to its uncertain size and its changing nature

as Carpenter and Krutka remind (2014). Marwick (2014) identifies several challenges of conducting survey through Twitter, considering that representativeness is one of the most problematic. Indeed, the operation of defining an audience on Twitter may be a problem by itself, and different solutions can be proposed. Bombaci, Farr, Gallo *et al.* (2016), for instance, in order to define an audience for tweets published along conference presentations at a Conservation Science Congress, decide to take retweeters as members of such an audience, because, at least, retweeters have read the message. However, this is but one of several possible approximations to Twitter audiences. In addition to Twitter changing nature, another complicating factor is immediacy (Marwick 2014), that in this study can explain, partly at least, the low rate of participation. On Twitter users are receiving constantly a lot of information and, with older tweets getting lost quickly in the timeline, potential respondents to our survey may have missed easily the link to the survey. Conversely, counting on researchers' support prevented that our message might be classified as spam.

## 2.4 Data analysis

Data were analyzed using Excel and SPSS 25, an IBM package for statistical analysis. Correlation tests were carried out when they were considered relevant. The Chi square test allows to measure correlations between nominal and ordinal data – such as those obtained in this survey – by comparing expected vs. observed frequencies in contingency tables. Unfortunately, the sample studied did not satisfied all requirements for the application of the Chi square test; specifically, in some cases the expected frequencies for some classes were not large enough (under 5) (Vaughan 2001, 88–91). As an alternative, variables were edited so that 2x2 contingency tables could be created, and the Fisher's exact test was carried out instead (Weinberg and Abramowitz 2008, 499). In order to find relationships between participants' occupation, on the one hand, and reasons for and consequences of following researchers on Twitter, on the other, occupations firstly were reduced to three categories: a) professionals, which included both those working in public administrations and in the private sector, b) the higher education sector, which covered researchers, teachers, and students, and finally c) a mixed group, with people working as professionals and in the education sector at the same time. Secondly, this last category that accounted for 11% of all participants was excluded from calculations in order to obtain a 2x2 contingency table. Similar mergings were conducted on the 4-level scales of the questions addressing the reasons for following and consequences of following researchers on Twitter. As a result, participants' answers were reduced to two groups, not or slightly applicable, and moderately and strongly applicable. In this way, Fisher's exact test could be carried out.

## 3. Results

### 3.1 Demographic data and general use of Twitter

The distribution of participants according to their sex is even, as 51% of respondents are male and 49 % female. Conversely, when grouped by age range, participants tend to concentrate in two out of five categories, specifically between twenty-six and forty years of age (41,5%) and between forty-one and fifty years of age (28,3) (Table 1).

AGE	%	Σ%
Under 25	5.7	5.7
Age 26-40	41.5	47.2
Age 41-50	28.3	75.5
Age 51-65	24.5	100
Over 65	0	100

Table 1. Participants distribution by age range

Participants were asked to grade their use of Twitter on a scale from 1 (“mostly personal use”) to 10 (“mostly professional use”). Twitter resulted as used mostly for professional (mean=7.4, median=8, mode=10, SD=2.4) than personal reasons. Participants were also asked to grade their participation on Twitter on a scale from 1 (“passive, I do not take part”) to 10 (“very active”), and they reported a moderately active participation (mean=6.6, median=7, mode=7, SD=2.1).

### 3.2 Participants’ main occupation and area of specialization

Participants could select more than one option in order to describe their main occupation, and the greatest percentage (60.4%) introduced themselves as professionals, working either in the public administration or in the private sector and as freelance (Table 2). Only 24.5% of participants introduced themselves as researchers, 18.9% as professors, and 20.7 as either postgraduate or undergraduate students.

Occupation	%
Researcher	24.5
Professional – public administration	41.5
Professional – private sector	13.2
Professional – freelance	5.7
Professor	18.9
Undergraduate student	7.5
Postgraduate student	13.2
Other	3.8

Table 2. Participants distribution by occupation

A subsequent classification based on participants’ responses allowed to produce 4 categories: 1) “Professionals”, which includes either those working in the public sector, the private sector or as freelance; 2) “Higher education/research”, which contains those who selected the option “researchers” or “professors”, and all students; 3) “Mixed”, which includes those that worked as professionals and at the same time as researchers or university professors or were also college students; 4) and finally, “Others”, i.e. all answers that could not be identified (Figure 1). Once more



professionals (49%) emerged above researchers (36%) as the most prominent occupation category in this sample.

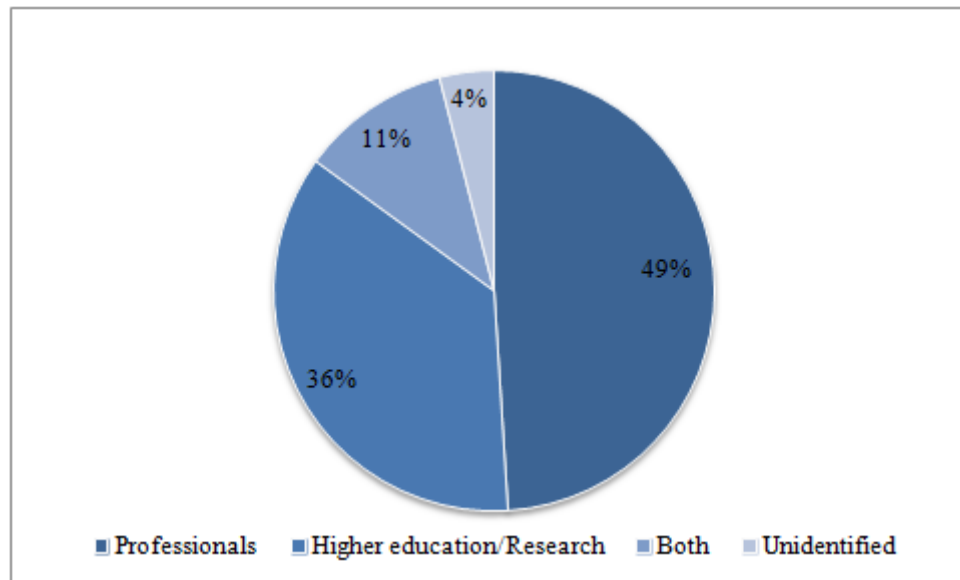


Figure 1. Participants distribution by main occupation

Finally, as for participants' main area of specialization, 81% of survey respondents indicated LIS, while the rest were experts in closely related fields such as journalism, economics, computer science or digital marketing.

### 3.3 Reasons for following and interacting with researchers on Twitter

Asked about the reasons for following researchers on Twitter, participants declared that they use Twitter basically to keep up to date (66%) and to obtain ideas for their work (50.9%), as shown in Figure 2 below. Also Twitter affords participants the possibility of showcasing their own work (35.8%), though it is less frequently used to interact and debate with other members, either professionals (17%) or scientists and researchers (9.4%). Interactions with professionals appear more common reasons for following researchers on Twitter than interactions with scientists and researchers. "Interacting and debating with professionals in my specialization" was never or slightly applicable for 45% of participants, and moderately and strongly applicable for 54.7% of participants. Conversely, "interacting and debating with scientists and researchers" was never or slightly applicable for 66% of participants, and moderately and strongly applicable for 33.9% of participants. "Getting closer to the world of science and research", however, is slightly or moderately applicable for 67.9%

of participants. Comments appended in a subsequent open-ended question underpinned Twitter's role as a source of ideas and information.

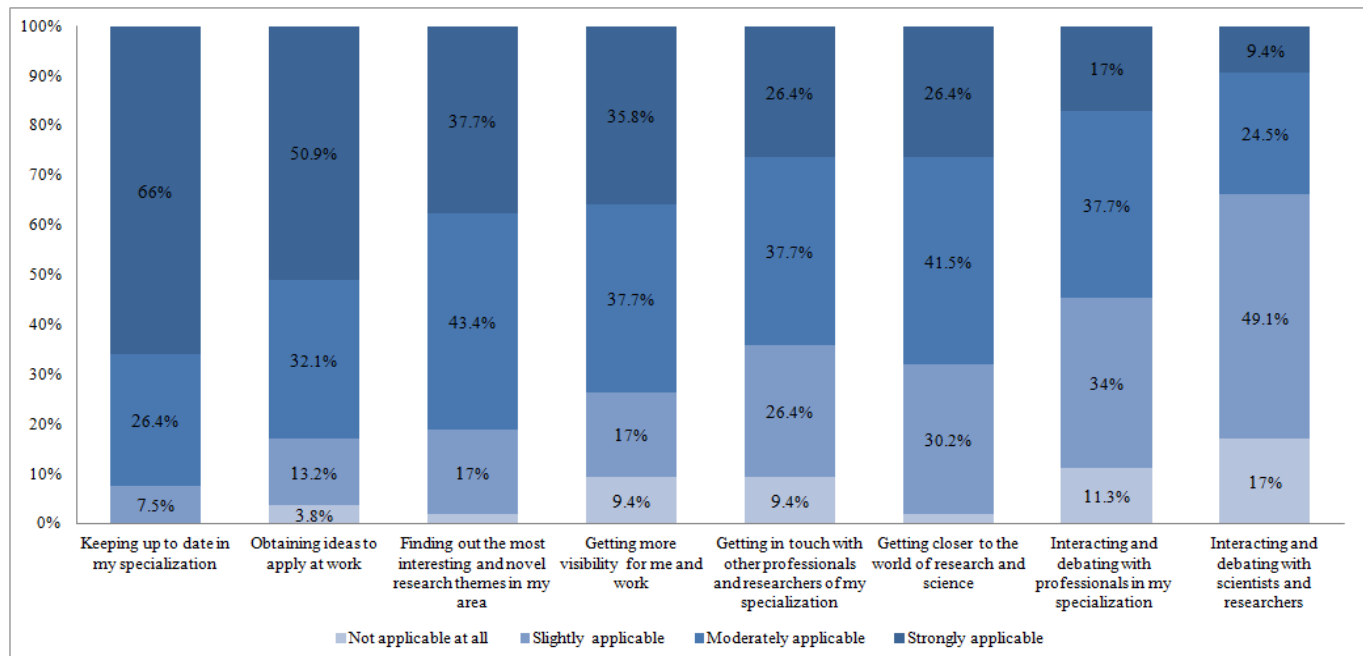


Figure 2. Reasons for following researchers on Twitter

The most common way of interaction is retweeting followed by mentioning, as 86.8% and 64% respectively of participants declared they did so often or almost always (Figure 3).

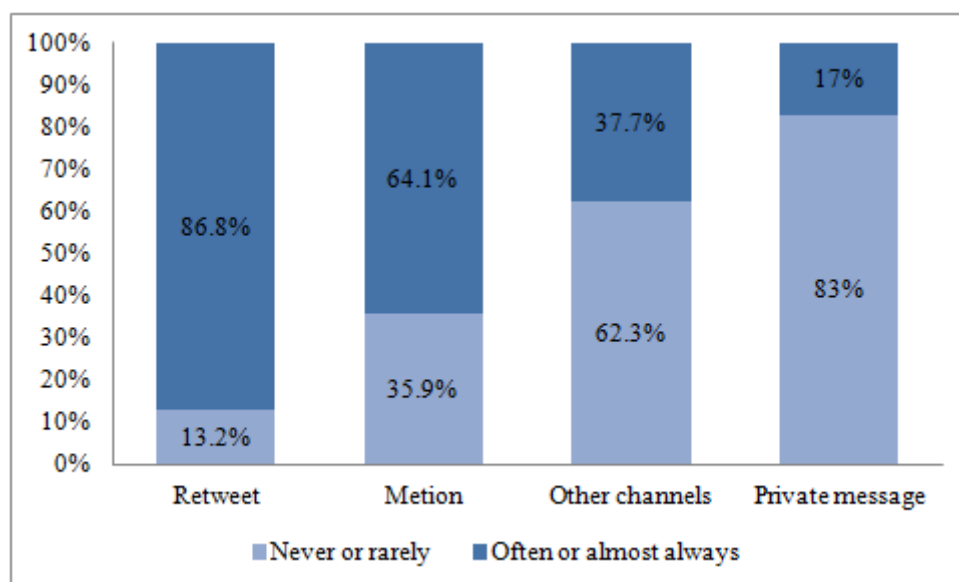


Figure 3. Types of interaction with other researchers on Twitter

Other communication channels are never or rarely used by 62.3% of participants, whilst sending private messages is something quite unusual (83% of participants used them never or rarely). The other channels of communication were specified in a subsequent open-ended question. Participants mentioned Facebook, email, WhatsApp, and other professional or academic social networks, such as LinkedIn, ResearchGate and Mendeley.

Figure 4 shows participants' reasons for interacting with researchers and other professionals on Twitter. Usually they do so to solve doubts and ask questions (54.7%) and provide more information (41.5%). On the other hand, becoming better known within the community appears to be a less common reason for interacting, as only 22.6% of respondents agreed on this. In a subsequent open-ended question, some of them considered that Twitter gave them the opportunity to find employment and make new contacts for future works or collaborations.

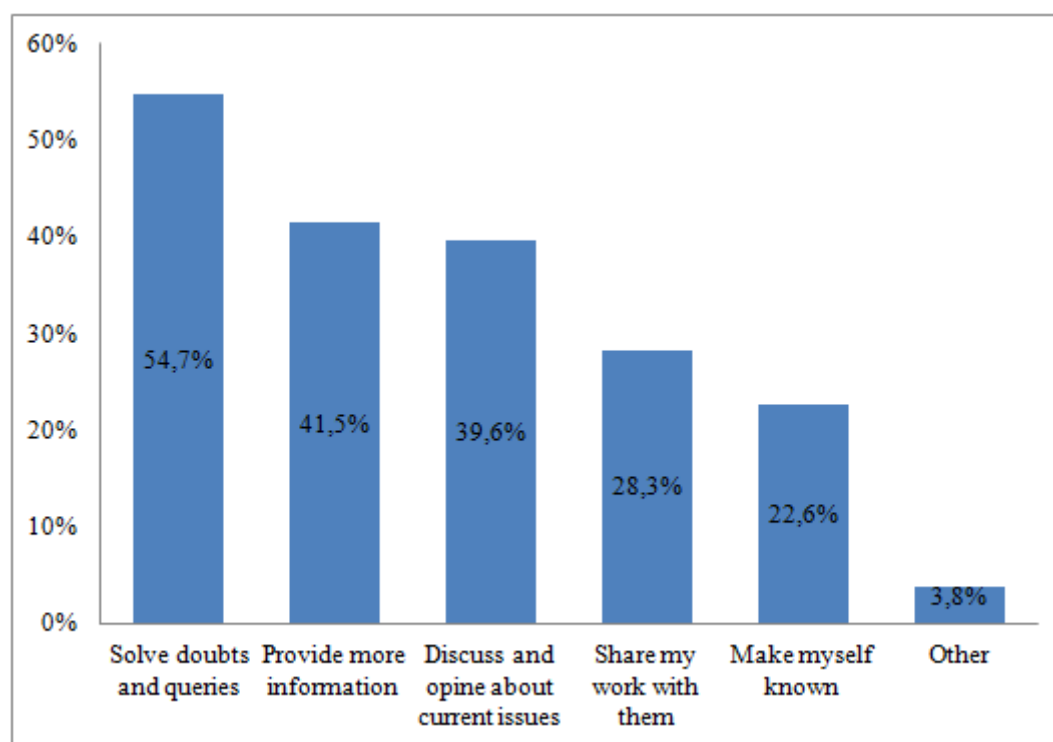


Figure 4. Reasons for interacting with researchers on Twitter

### 3.4 Results of following researchers or professionals on Twitter

Most of the participants agreed to different extents that, as a result of following other users on Twitter, it is easier to keep up to date (85%) as well as implement new scientific and technical advances in their professional areas (79%). Respondents also reported that they felt more motivated with their field of specialization (81.1%), increased their professional circle (77.4%) and perceived themselves

as members of a professional or scientific community (75.5%). Strikingly, most respondents (67.9%) felt that following researchers on Twitter did not allow them to influence research trends (Figure 5).

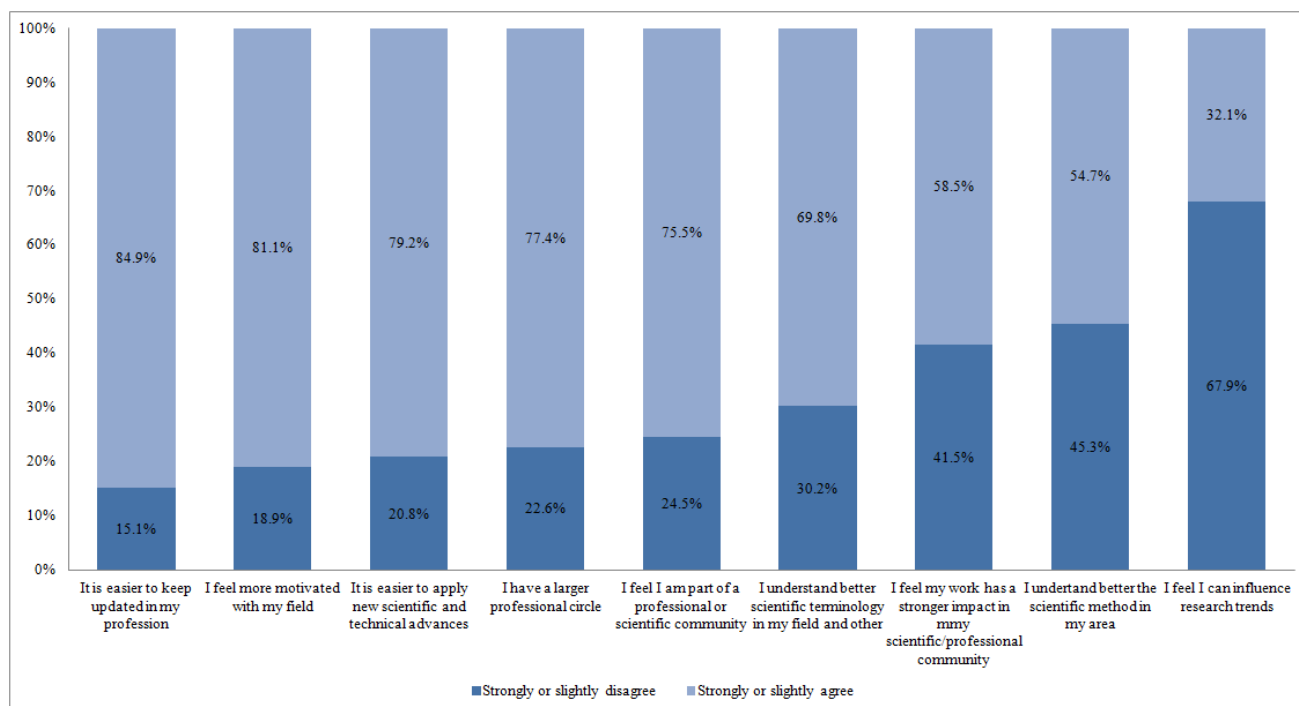


Figure 5. Consequences of following researchers on Twitter

### 3.5 Correlation tests

The Fisher's exact test was run in order to test the null hypothesis that there was no differences between professionals and members of the higher education sector as for the reasons and consequences of following researchers on Twitter. However, in no case could the null hypothesis be rejected, which means that participants' occupation appears to have no influence on the reasons for following researchers on Twitter nor on the consequences of doing so. Similarly, Fisher's exact test was run to look for a possible relationship between the channel preferred for interacting on Twitter (retweet, mention, private message, or other channels) and occupation. As in the previous cases, the null hypothesis could not be rejected.

## 4. Discussion and conclusions

### 4.1 Limitations

In the introduction of this research paper we wondered what kind of audience followed researchers on Twitter, and whether the interactions between researchers and their followers could be looked at as "productive interactions", i.e. as encounters in which science somehow makes its way to society. The answers provided here proceed from a survey with 53 Twitter users who were also followers of

active Spanish researchers in the area of LIS. This sample is indeed little representative, though we already explained that certain characteristics of Twitter by themselves make it difficult to reach followers as potential respondents, whilst poor response rates appear in other similar Twitter surveys such as Mohammadi, Thelwall, Kwasny *et al.* (2018). Another limitation is that we studied a single interdisciplinary discipline, LIS, and research-society interactions depend highly on the field studied (De Jong, Barker, Cox *et al.* 2014). According to Chikoore, Proberts, Fry, *et al.* (2016), academics working in pure sciences look at the general public as a more relevant audience than academics working in applied disciplines. Notwithstanding these limitations, considering that little research has been published on this topic (Ke, Ahn, and Sugimoto 2017; Mohammadi *et al.* 2018) and considering as well the demand for more survey research as explained in the introduction, this study adds some knowledge about the identities, reasons and expectations of those following researchers on Twitter, and allows to describe, to a certain extent, the interactions taking place between researchers and their followers on Twitter.

#### 4.2 Who is interacting with researchers on Twitter?

According to the results obtained, it can be concluded that the researchers studied here are followed mostly by professionals (49%), though the higher education sector (including researchers, professors, and students) accounts for an important part of the audience (36%). This means at least that professionals are interested in knowing what researchers are saying on social web media, confirming the results of Mohammadi *et al.* (2018) survey in which practitioners resulted as a secondary though important group of people tweeting academic articles only preceded by the scientific community itself. Budge *et al.* (2016), reflecting on their participation on Twitter as academics, use the concept of “messy identities” to describe the fact that, on Twitter, they can perform indifferently as artists and academics. Conversely, in this study, participants presented themselves mostly as professionals, secondarily as members of the higher education sector, and only to a minor extent as both of this (11%), which means that they did not perceive their identity as “messy”. Additionally, they look at Twitter more as a tool for professional than personal communication. The prevalence of professionals might be a characteristic of LIS more than a feature of the sample studied here. A 2002 survey (Powell, Baker and Mika 2002) found that 89% American and Canadian LIS practitioners read scientific literature on a regular basis, and almost 40% had engaged in actual research occasionally or frequently. LIS practitioners might be more inclined than practitioners in other areas to have an interest for research, and this might have affected results.

#### 4.3 What kind of interactions?

The kind of activity that participants perform on Twitter consists mostly of keeping updated (strongly or moderately applicable in 92% cases), obtaining ideas to implement in one’s own work (strongly or moderately applicable in 83% cases), finding out the most interesting and novel research themes in their area (strongly or moderately applicable in 81% cases), and working for one’s own visibility (strongly or moderately applicable in 73% cases). These reasons for following researchers on Twitter differ only to a certain extent from the reasons for publishing on academic or professional journals that Clapton (2010) described studying 100 UK-based LIS practitioners. Clapton (2010) found that



practitioners publish mainly to share their ideas with others (84%), secondly for professional development (78%), and thirdly to raise their profile (47%), something that, transferred to the social web, can be seen as shaping one's own visibility. Being on Twitter appears as something similar, probably alternative, to publishing academic literature, with the difference that on Twitter this activity is public. Haustein *et al.* (2014) found that publishing on Twitter and publishing scientific literature were to some extent alternatives for a sample of very active physicists on Twitter, who tended to be less productive in terms of scientific publications.

Interactions appear as an important though secondary facet of these users' activity on Twitter. They take place more often with other professionals (strongly or moderately applicable in 54% cases) than with researchers or scientists (strongly or moderately applicable in 33% cases). The types of interactions performed on Twitter are highly dependent on the affordances of the platform. Interaction occurs mostly by retweeting (used often or almost always by 86% of participants) or mentioning (used often or almost always by 64% of participants), i.e. two Tweeter-specific communication devices. Other channels of communication are used often or almost always in 37.7% of cases. There are no differences in the form of interaction chosen between professionals and the higher education sector. Nor are there differences between professionals and the higher education sector as for the reasons for following researchers on Twitter and for the consequences of following them. The interactions described by the sample studied here are clearly Twitter-shaped interactions. Draucker (2015) characterizes communication on Twitter as an interaction between "broadcasters" and "followers", contending that the characteristics of the medium affect the nature of communication, and that participation frameworks need to be studied in order to understand the specificities of communication on new media. Following Draucker (2015), the possibility of addressing them converts broadcasters into participants in the communication. However, the audience studied here, which is mainly made up of professionals, reported that interactions occur more with other professionals than scientists and researchers, who appear as a less approachable target.

As a consequence of this activity as Twitter followers, more than three quarters of participants agreed to different extents that they could more easily keep updated and implement technical and scientific advances in their daily practice, they felt more motivated, and they felt as part of a community. On other dimensions more related to the social reach of science and research, responses were less clear-cut, though meaningful. For instance, almost 70% and 54.7% of participants felt that they understand better, respectively, the scientific terminology and the scientific method. Conversely only 32.1% considered that they can influence research trends – and 67.9% straightly disagreed on this. It is difficult to say if this perceived little influence on research trends is really a consequence of being a follower in a mostly "unidirectional" flow of information, in which participants interact mostly by retweeting, i.e. forwarding information to their own followers. Whatever the reason, communication flows on Twitter sometimes appear to be at least "mismatched". Bombaci *et al.* (2016), for example, studied tweets published during a conference of Conservation Biology. The authors, mainly academics, intended to reach, in order of importance, other academics, government agencies and policy makers, though actually it appeared that most tweets reached twice as much as intended to other academics, less than one-fourth as much as intended government agencies, whilst policy makers were not reached at all. In Bombaci *et al.*'s study broadcasters appeared to have little control over

their followers, whereas in our study followers interacted back with researchers and scientists rarely. Müllerleile (2014) warns that social media alone may fail as a strategy for engagement with the public, though they work well for disseminating contents in combination with other tools. The results of Bornmann (2018) point to the same direction concluding that altmetrics might reveal the degree of unknown attention paid to research more than the link between research and action in society.

It is difficult to say if the followers' activity described here qualify as a type of "productive interaction" because the concept itself of productive interaction is still undetermined and mostly analyzed in case-study approaches (Spaapen and Van Drooge 2011; De Jong *et al.* 2014). The results of this study allow to conclude that the knowledge acquired by following researchers on Twitter definitively is relevant, considering participants' claims about the consequences of following researchers on Twitter. However, it cannot be said if it is robust. Concerns about the veracity and the proper interpretation of the scientific knowledge on social media exist, especially in disciplines such as conservation science (Darling, Shiffman, Cote *et al.* 2013; Bombaci *et al.* 2016). On the other hand, the interaction described here appears scarcely interdisciplinary, as only 19% of participants belong to disciplines others than LIS, confirming previous results. De Jong *et al.* (2014) contend that, when societal impact of research is under evaluation, researchers in other research fields should be considered as important stakeholders. In this sense, the monodisciplinary interactions described here do not appear meaningful in a societal perspective, as they don't in similar studies of research communities on Twitter. The monodisciplinary nature of communities around scientific profiles on Twitter appears also in Ke, Ahn and Sugimoto (2017), who identify more than 45000 scholarly profiles on Twitter, and conclude that scholars tend to follow profiles of their same discipline across all disciplines. Participating on Twitter makes participants more acquainted with science and research in terms of implementation of research findings, and comprehension of research terminology and research methods. Indeed, knowledge acquired on Twitter has an application in the participants' professional sphere, a condition that Spaapen y van Drooge (2011) emphasized for interactions to be productive. However, the results of this study do not allow to describe exhaustively the type of relational engagement taking place among the researchers broadcasting and the audience following them. Some of the results point to a mainly unidirectional flow of information in which followers feel that they have little influence on the activities performed by broadcasters (the researchers). Conversely, when the assessment of societal impact of research is concerned, it is understood that knowledge dissemination occurs in complex multidirectional networks (Spaapen and Van Drooge 2011; Ozanne *et al.* 2017) or at least in bidirectional interactions (Greenhalgh *et al.* 2016). The question we should address in future research is whether being on Twitter has some implications on research activities as well, in the sense of reflecting societal concerns and problems as discussed and proposed by followers. Recent research points to the fact that the research articles discussed on Twitter tend to be more broadly oriented than research articles in general, at least within the area of climate change (Haunschild, Leydesdorff, Bornmann *et al.* 2018). If it might reveal certain awareness of the audience, it does not guarantee that a real communication with the public occurs.

As a conclusion, it can be said that being a follower on Twitter accomplishes for the professionals surveyed here a similar role to publishing, in the sense of exchanging ideas and gaining visibility through participation and presence in a monodisciplinary community. The scientific communication system allows scientists to participate in knowledge production abiding by specific rules, such as citing

previous relevant work. In this study, participation rules are defined to an important extent by the affordances of the platform itself. From this point of view, interactions on Twitter do not allow easy engagement because information flows mostly in a unidirectional way and researchers' followers act mainly as retweeters of the information they receive. There are clear advantages for the participants who follow our sample of researchers, which derive from being part of a Twitter community. However, their ability to truly interact is limited and as a consequence it seems that they have little influence on research and researchers. Future research should address this question from the point of view of researchers, and better document in LIS and other areas how interactions on social media occur and with whom. Only when researchers' interactions on the social web are really proved to reveal some kind of societal impact, an important issue to address in future altmetrics research will be how to quantify and measure interactions and engagement.

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